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(12) **United States Patent**
Nakamura

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(45) **Date of Patent: Jun. 7, 2016**

(54) **LIGHTING DEVICE**

(71) Applicant: **Enplas Corporation**, Saitama (JP)

(72) Inventor: **Masato Nakamura**, Saitama (JP)

(73) Assignee: **Enplas Corporation**, Saitama (JP)

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F21V 7/04 (2006.01)
F21V 13/04 (2006.01)
F21K 99/00 (2016.01)

(52) **U.S. Cl.**

CPC ***F21V 13/04*** (2013.01); ***F21K 9/135*** (2013.01); ***F21K 9/1355*** (2013.01); ***F21K 9/50*** (2013.01)

(58) **Field of Classification Search**

CPC F21V 5/045; F21V 7/0008; F21V 7/041; F21V 13/04; F21V 17/12
IPC F21V 5/045
See application file for complete search history.

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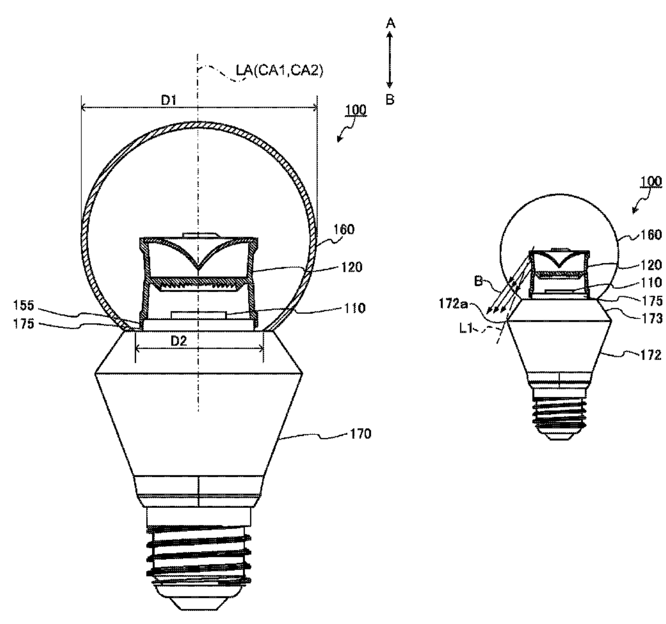
Primary Examiner — Julie Bannan

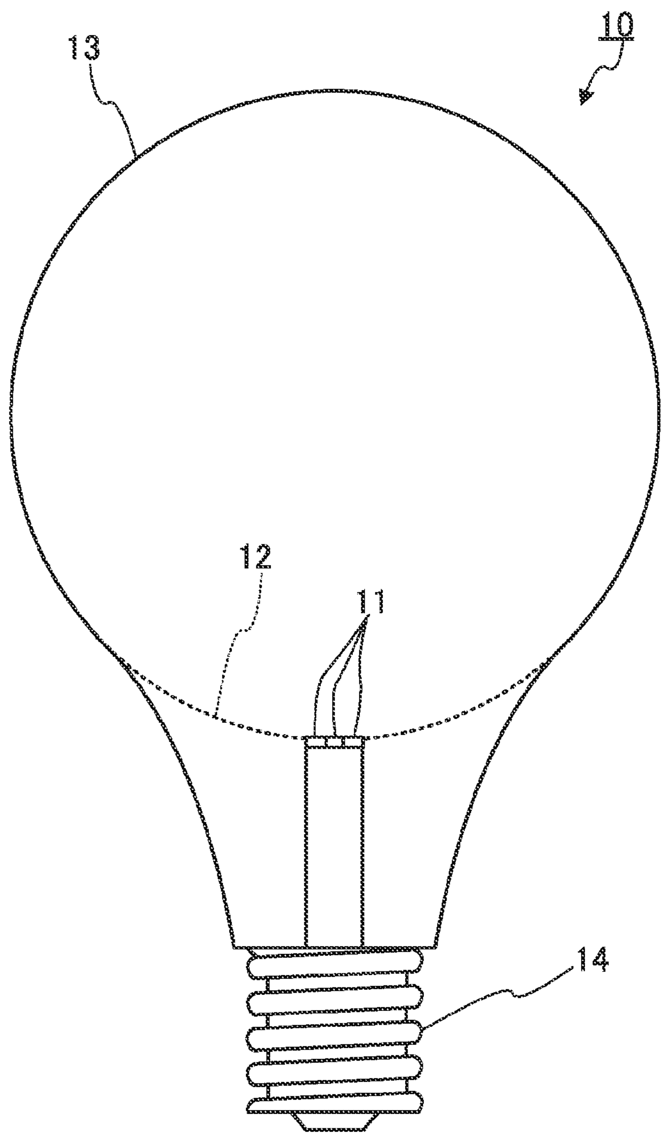
(74) *Attorney, Agent, or Firm* — Brundidge & Stanger, P.C.

(57) **ABSTRACT**

The present invention relates to a lighting device. Light flux controlling member **120** of lighting device **100** according to the present invention distributes light emitted from light emitting element **110** at least sideward and rearward. The light emitted from light flux controlling member **120** is diffused and transmitted to a cover. Housing **170** is formed in a shape that does not block a main component of the light emitted rearward from light flux controlling member **120**. Lighting device **100** can distribute the emitted light from light emitting element **110** forward, sideward and rearward in all directions.

3 Claims, 14 Drawing Sheets





PRIOR ART

FIG. 1

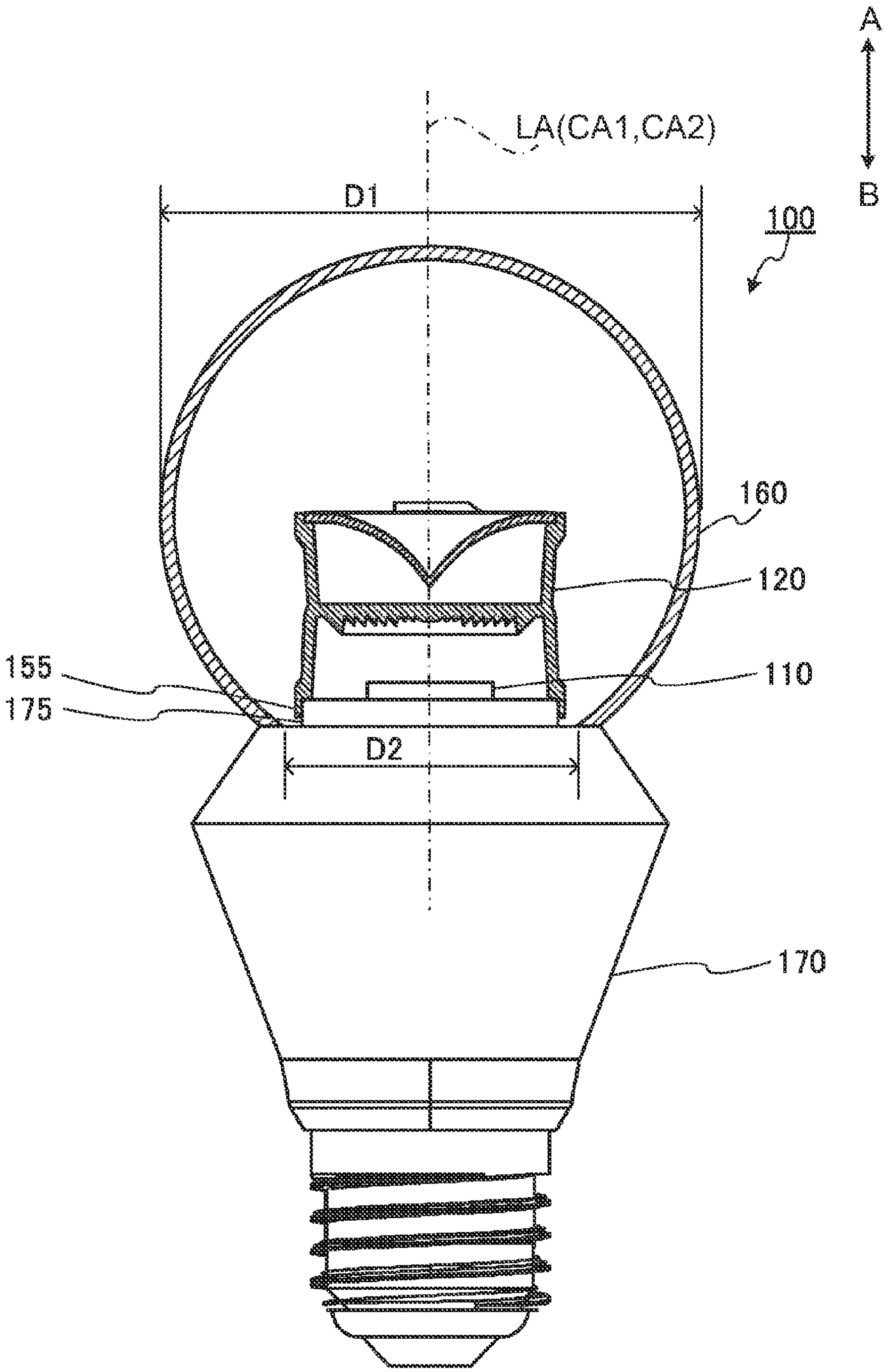


FIG. 2

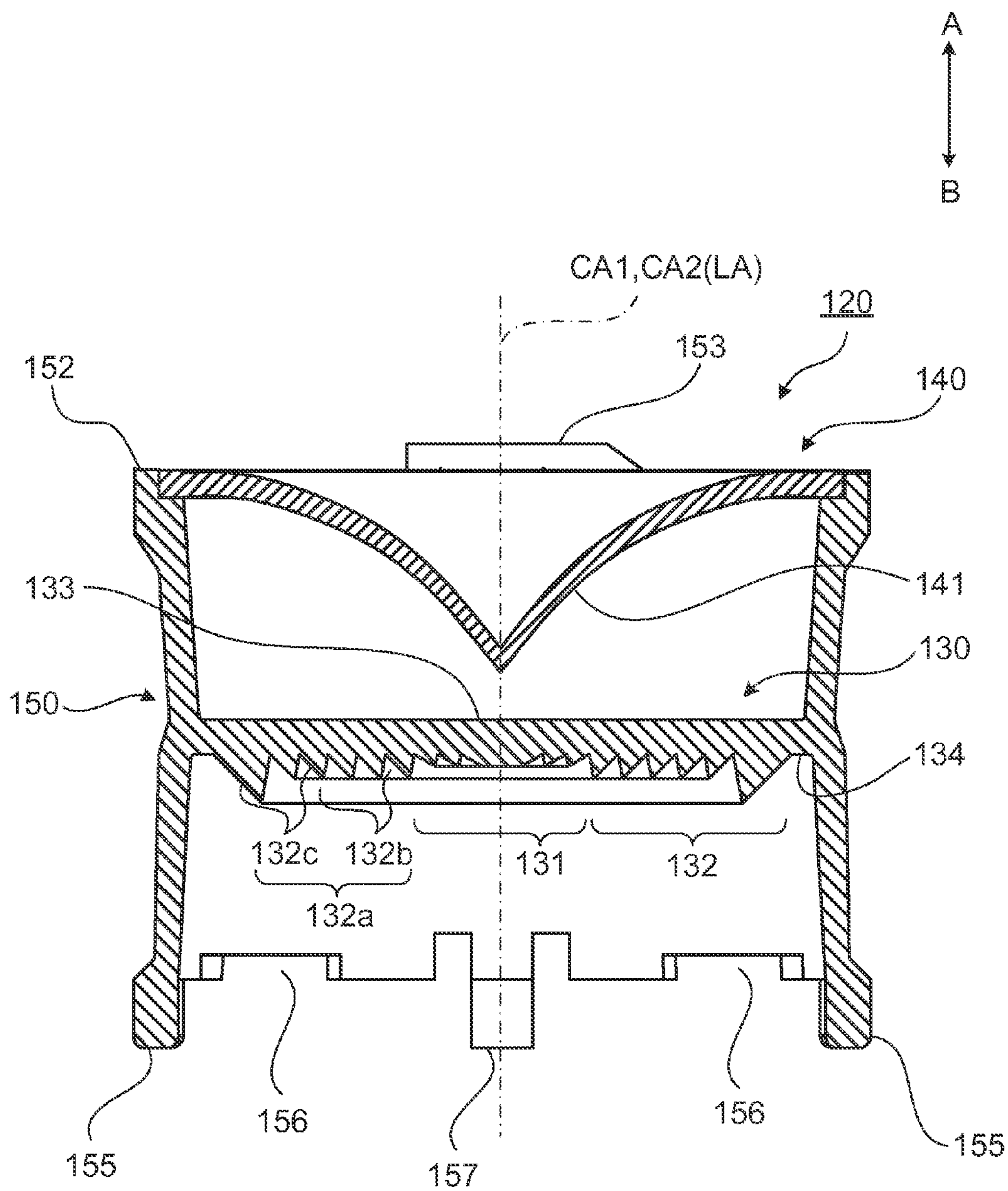

A
B
CA1,CA2(LA)
120
153
140
152
141
133
130
150
134
132c
132b
131
132
132a
155
156
157
156
155

FIG. 3

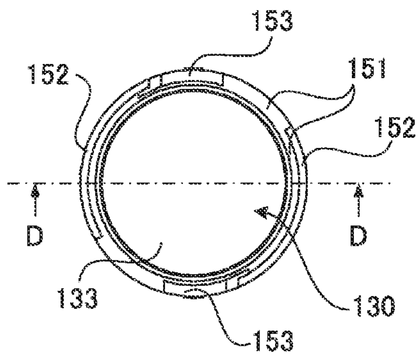


FIG. 4A

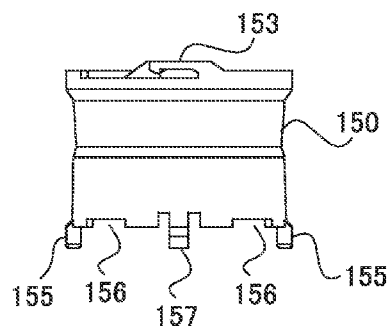


FIG. 4B

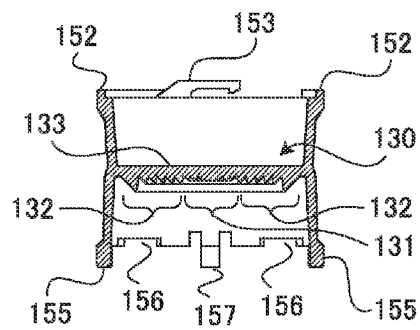


FIG. 4D

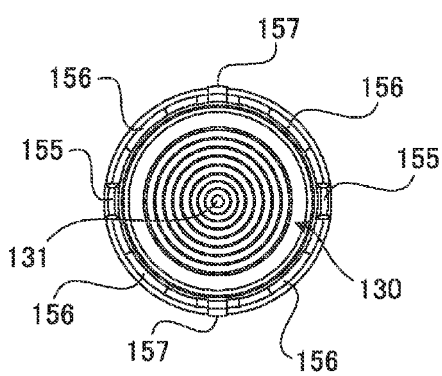


FIG. 4C

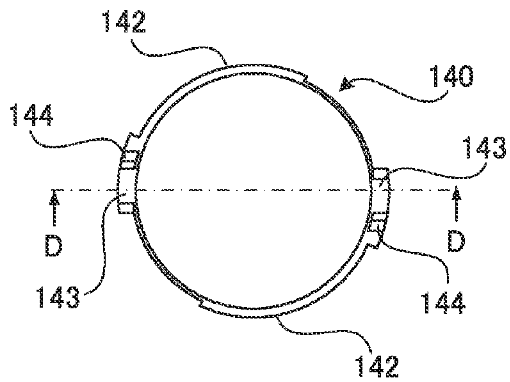


FIG. 5A

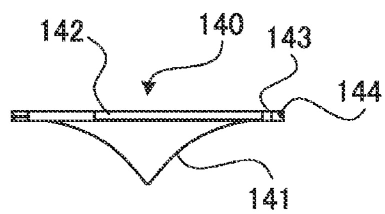


FIG. 5B

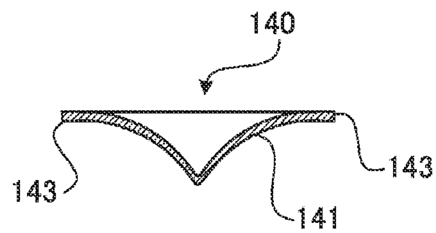


FIG. 5D

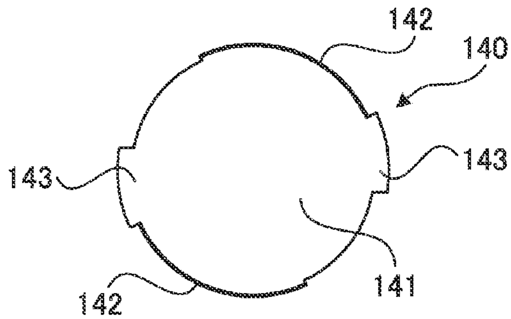


FIG. 5C

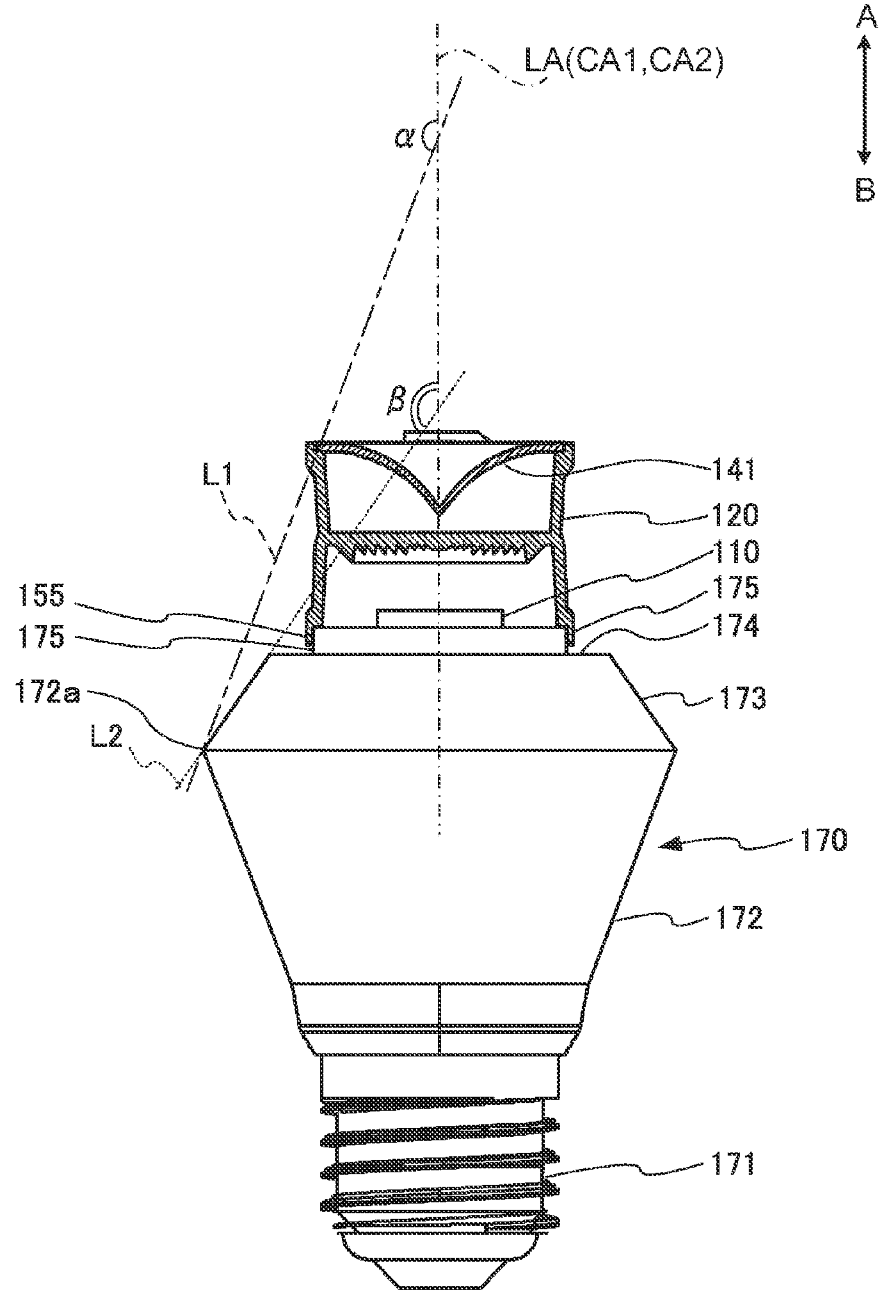

A
B
LA(CA1,CA2)
α
β
L1
141
120
110
175
155
175
174
172a
173
L2
170
172
171

FIG. 6

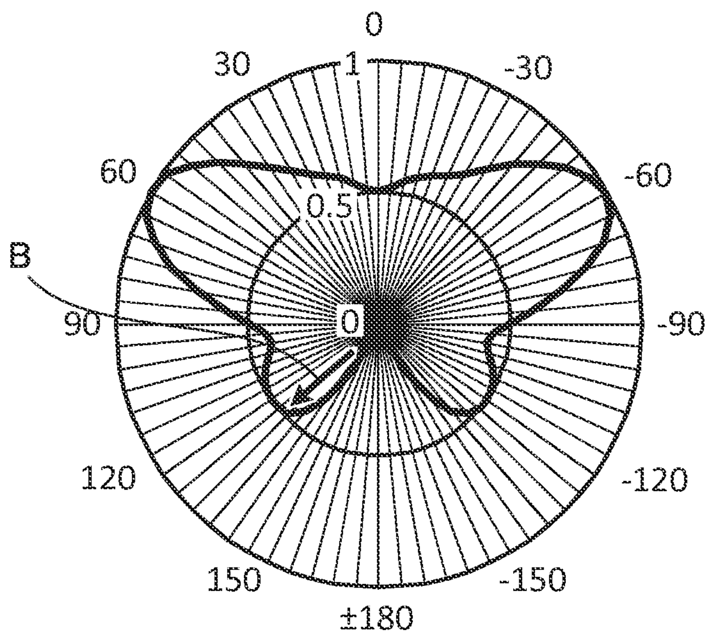


FIG. 7

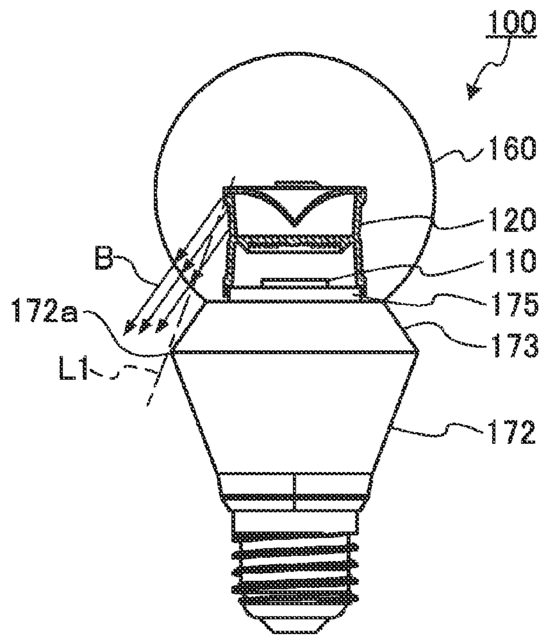

100
160
120
110
175
173
172
B
172a
L1

FIG. 8A

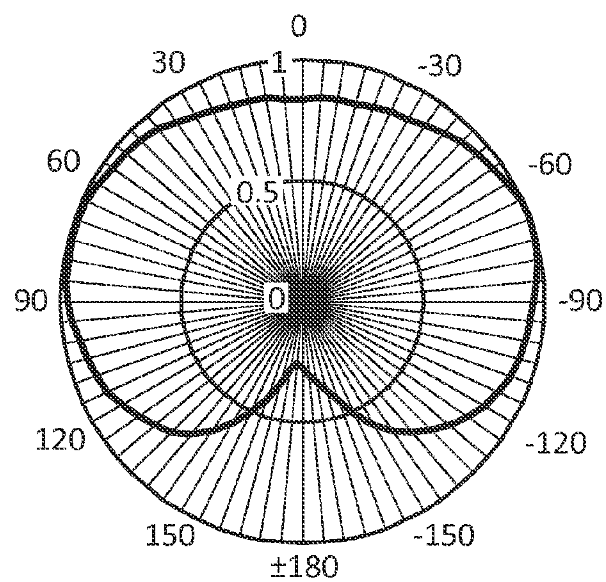

0
30
-30
1
60
-60
0.5
90
0
-90
120
-120
150
-150
±180

FIG. 8B

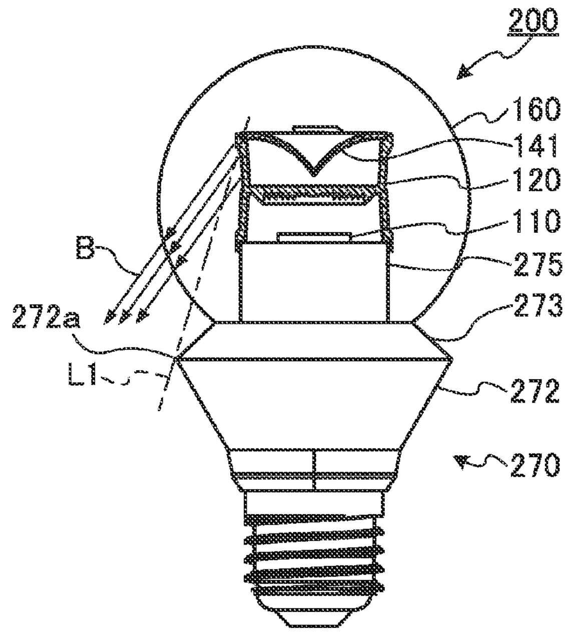
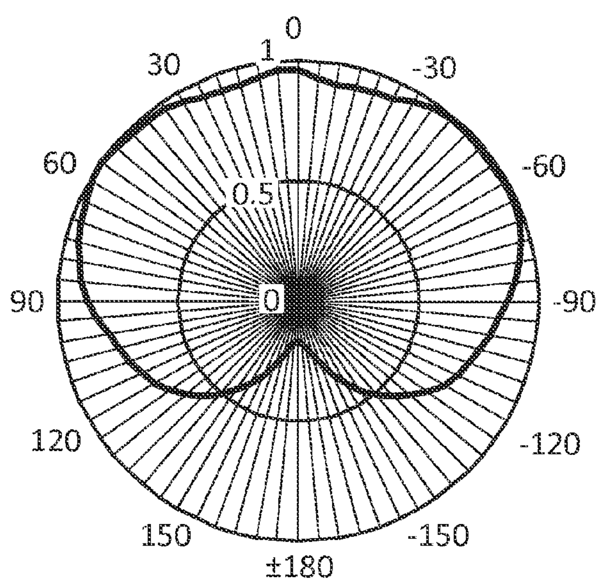

200
160
141
120
110
B
275
272a
273
L1
272
270

FIG. 9A


0
1
30
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-60
0.5
90
0
-90
120
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150
-150
±180

FIG. 9B

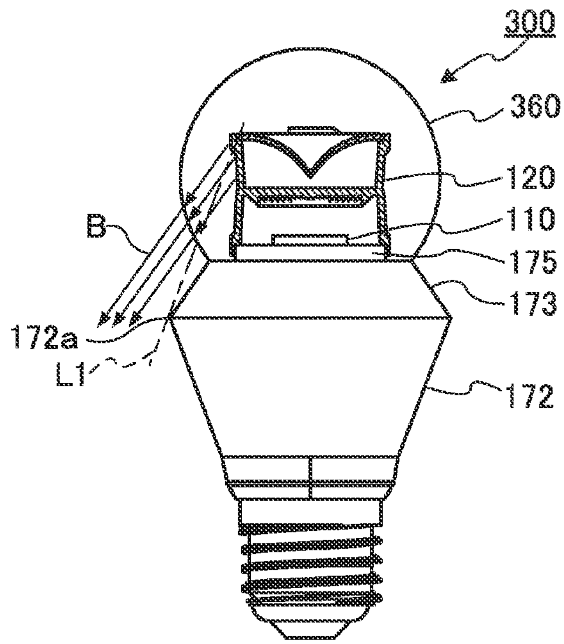


FIG. 10A

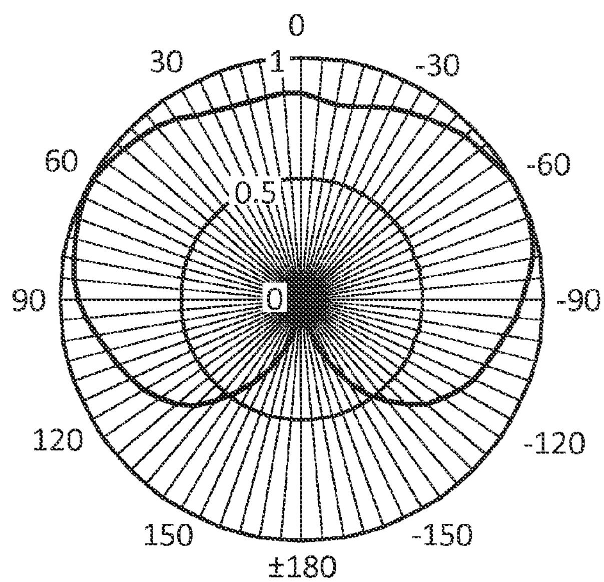
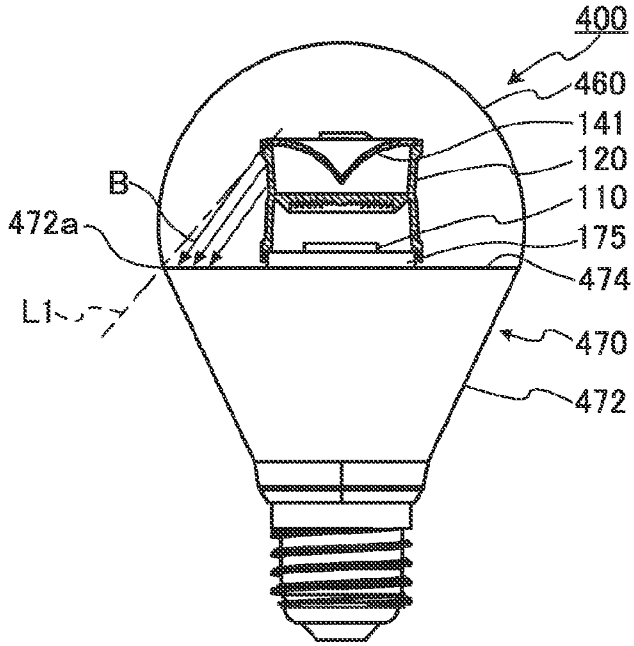


FIG. 10B



PRIOR ART

FIG. 11A

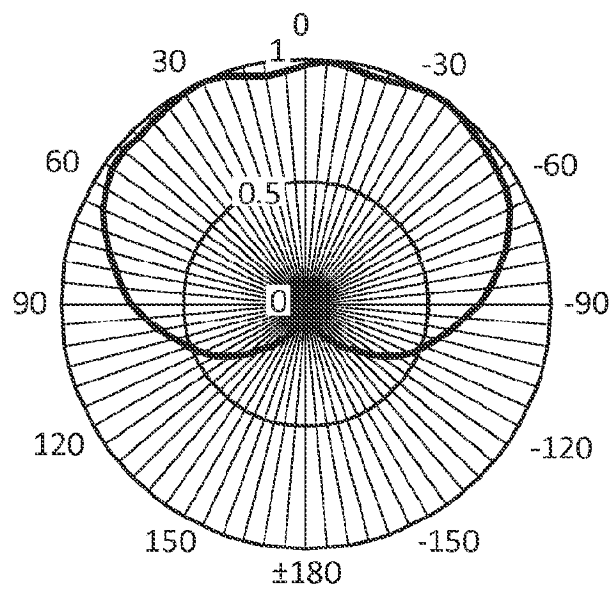
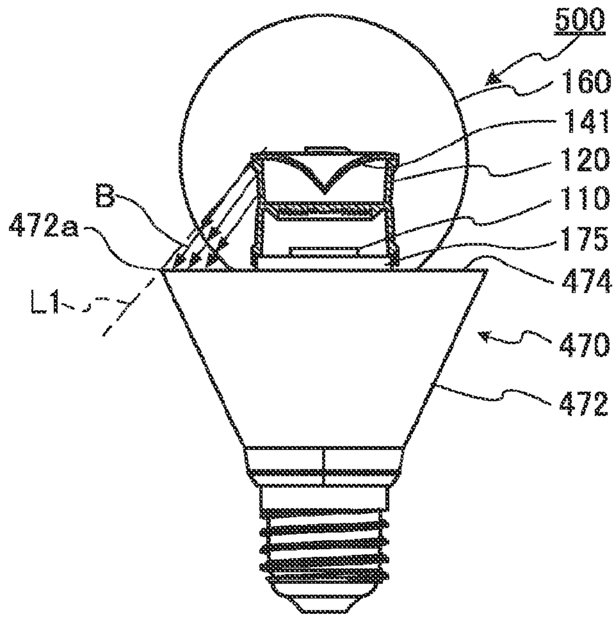


FIG. 11B



PRIOR ART
FIG. 12A

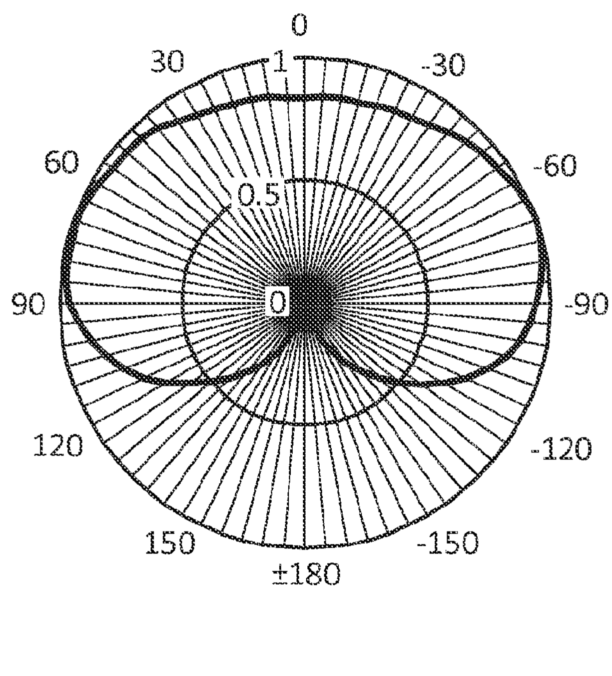


FIG. 12B

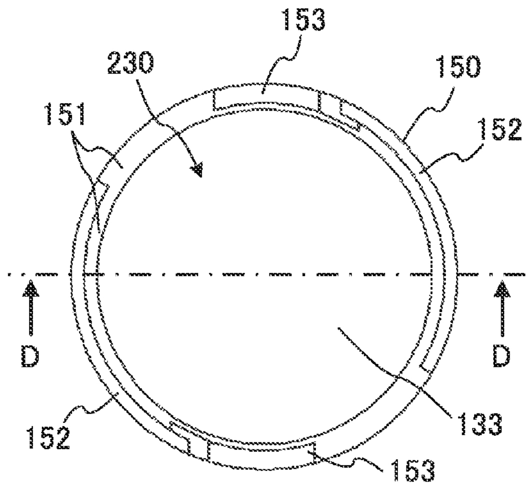


FIG. 13A

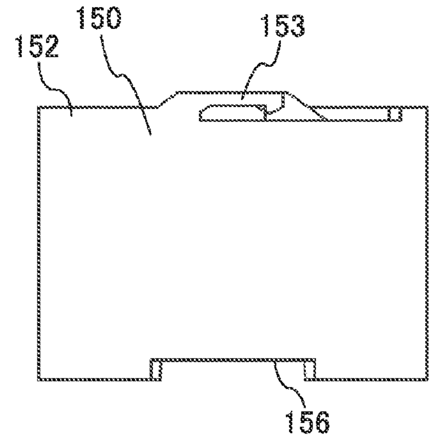


FIG. 13B

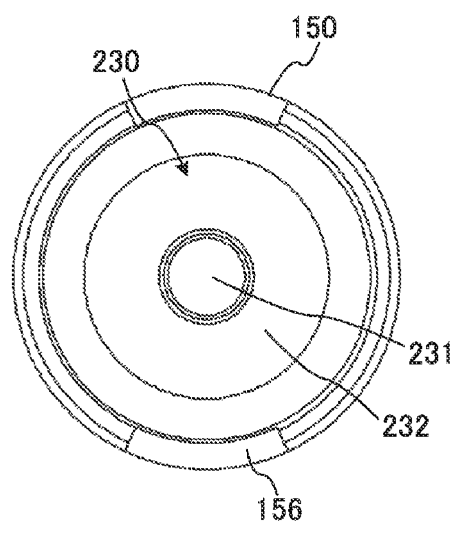


FIG. 13C

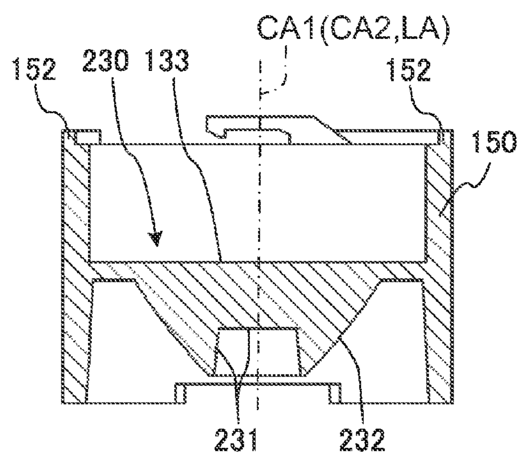


FIG. 13D

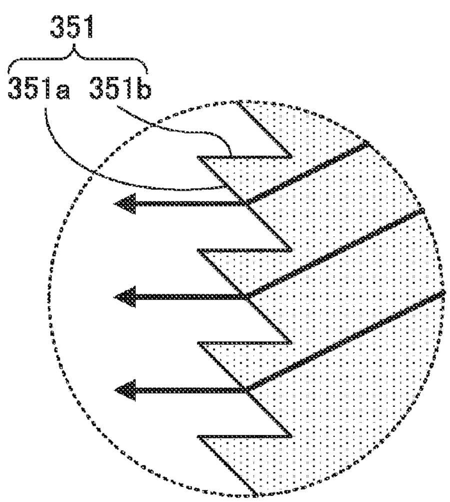


FIG. 14A

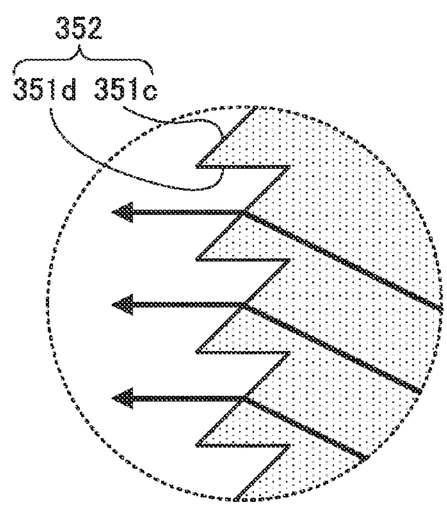


FIG. 14B

LIGHTING DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is entitled to and claims the benefit of Japanese Patent Application No. 2012-255939, filed on Nov. 22, 2012, the disclosure of which including the specification, drawings and abstract is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present invention relates to a lighting device having a light emitting element.

BACKGROUND ART

In recent years, from a viewpoint of saving energy and protecting environment, a lighting device (for example, LED light bulb) whose light source is a light emitting diode (hereinafter, also referred to as an "LED") has been used in place of an incandescent lamp.

As such a lighting device, a lighting device illustrated in FIG. **1** has been known (for example, refer to PTL 1). FIG. **1** is a schematic diagram illustrating a configuration of the lighting device disclosed in PTL 1. Lighting device **10** illustrated in FIG. **1** has LED **11** in the center, light emission surface **12** which emits light forward, substantially spherical-shaped cover **13** which is integrally formed from light emission surface **12**, and Edison screw **14** which is connected to LED **11** and cover **13**. Lighting device **10** is formed into a shape similar to the incandescent lamp as a whole.

CITATION LIST

Patent Literature

PTL 1
Japanese Patent Application Laid-Open No. 2011-165675

SUMMARY OF INVENTION

Technical Problem

Light distribution of the lighting device disclosed in PTL 1 is determined only by light diffusion of the cover, thereby the light distribution being biased forward. Accordingly, the lighting device cannot emit light toward a wide range direction like the incandescent lamp. Therefore, the lighting device cannot extensively illuminate a room by using reflected light from a ceiling or a wall surface like the incandescent lamp.

The present invention provides a lighting device which has a light emitting element and can distribute light toward a forward, lateral and rear directions of the lighting device.

Solution to Problem

A lighting device according to the present invention includes: a light emitting element for emitting light toward a forward direction of the lighting device;

a light flux controlling member for emitting a part of light, the light being emitted toward the forward direction from the light emitting element, toward a lateral direction or a rear direction of the lighting device, the light flux controlling member being arranged on an optical axis of the light emitting element, and comprising a first light flux controlling member and a second light flux controlling member;

a cover that covers the light flux controlling member for transmitting light emitted from the light flux controlling member with the light being diffused; and

a housing that supports the light emitting element, the light flux controlling member and the cover,

wherein the first light flux controlling member is arranged opposing the light emitting element for emitting a part of light that is emitted from the light emitting element and reaches the first light flux controlling member toward the second light flux controlling member,

the second light flux controlling member has a reflection surface that faces to an emission surface of the first light flux controlling member for reflecting a part of light emitted from the first light flux controlling member and reaches the second light flux controlling member, and for transmitting the remaining light,

the reflection surface is a rotationally symmetric surface whose rotation axis is the optical axis, and a generating line of the rotationally symmetric surface is formed to be a concave curve with respect to the first light flux controlling member,

an outer peripheral portion of the reflection surface is disposed at a position away from the light emitting element in a direction of the optical axis, compared to a central portion of the reflection surface, and

the housing is formed into a shape so that α is θ or greater in any cross-section including the optical axis, where α is one of two obtuse angles formed between an extension line of a tangent that comes into contact with the housing from an outer rim of the reflection surface and the optical axis, the α being the one obtuse angle positioned more forwardly than the other obtuse angle; and θ represents an angle of an emitting direction of light that indicates peak intensity at rearward in distribution of luminous intensity of the light emitted from the light flux controlling member, provided that an angle of an emitting direction of light emitted forward from the light flux controlling member along the optical axis is set to 0°.

Advantageous Effects of Invention

The lighting device according to the present invention can distribute light toward a forward, lateral and rear directions of the lighting device. Therefore, according to the present invention, there is provided a lighting device which can distribute the light toward a forward, lateral and rear directions of the lighting device with good balance and can extensively illuminate a room by utilizing the light reflected from a ceiling or a wall surface like an incandescent lamp.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic view illustrating a configuration of a lighting device disclosed in PTL 1;

FIG. **2** is a cross-sectional view of a main portion of a lighting device according to Embodiment 1 of the present invention;

FIG. **3** is a cross-sectional view of a light flux controlling member according to Embodiment 1;

FIG. **4A** is a plan view of a first light flux controlling member and a holder according to Embodiment 1; FIG. **4B** is a side view of the first light flux controlling member and the holder; FIG. **4C** is a bottom view of the first light flux controlling member and the holder; FIG. **4D** is a cross-sectional view of the first light flux controlling member and the holder along a line D-D illustrated in FIG. **4A**;

FIG. **5**A is a plan view of a second light flux controlling member according to Embodiment 1; FIG. **5**B is a side view of the second light flux controlling member; FIG. **5**C is a bottom view of the second light flux controlling member; FIG. **5**D is a cross-sectional view of the second light flux controlling member along the line D-D illustrated in FIG. **5**A;

FIG. **6** is a view for explaining angles α and β in the lighting device according to Embodiment 1;

FIG. **7** is a graph illustrating light distribution of the light flux controlling member according to Embodiment 1 by using a relative value of luminous intensity;

FIG. **8**A is a view schematically illustrating light emitted toward a rear direction of the lighting device according to Embodiment 1; FIG. **8**B is a graph illustrating the light distribution of the lighting device by using the relative value of the luminous intensity;

FIG. **9**A is a view schematically illustrating light emitted toward a rear direction of a lighting device according to Embodiment 2; FIG. **9**B is a graph illustrating the light distribution of the lighting device by using the relative value of the luminous intensity;

FIG. **10**A is a view schematically illustrating light emitted toward a rear direction of a lighting device according to Embodiment 3; FIG. **10**B is a graph illustrating the light distribution of the lighting device by using the relative value of the luminous intensity;

FIG. **11**A is a view schematically illustrating light emitted toward a rear direction of a lighting device according to Comparative Example 1; FIG. **11**B is a graph illustrating the light distribution of the lighting device by using the relative value of the luminous intensity;

FIG. **12**A is a view schematically illustrating light emitted toward a rear direction of a lighting device according to Comparative Example 2; FIG. **12**B is a graph illustrating the light distribution of the lighting device by using the relative value of the luminous intensity;

FIG. **13**A is a plan view of an integrally molded product of a first light flux controlling member and a holder according a modification example of the present invention; FIG. **13**B is a side view of the integrally molded product; FIG. **13**C is a bottom view of the integrally molded product; FIG. **13**D is a cross-sectional view of the integrally molded product along the line D-D illustrated in FIG. **13**A; and

FIG. **14**A is a view illustrating an example of enlarged irregularities formed on an outer peripheral surface of the holder; FIG. **14**B is a view illustrating another example of the enlarged irregularities formed on the outer peripheral surface of the holder.

DESCRIPTION OF EMBODIMENTS

Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings. In the following description, as a representative example of a lighting device according to the present invention, a lighting device will be described which can be used in place of an incandescent lamp.

(Embodiment 1)

(Configuration of Lighting Device)

FIG. **2** is a cross-sectional view illustrating a configuration of a lighting device according to Embodiment 1 of the present invention. As illustrated in FIG. **2**, lighting device **100** has light emitting element **110**, light flux controlling member **120**, cover **160** and housing **170**. Hereinafter, each configuring element will be described.

(1) Light Emitting Element

Light emitting element **110** is a light source of lighting device **100** and is mounted on housing **170**. For example, light emitting element **110** is a light emitting diode (LED) such as a white light emitting diode. The number of light emitting elements **110** may be one or more. The term "optical axis of the light emitting element" means a travelling direction of light at the center of a three-dimensional light flux from the light emitting element. If two or more light emitting elements are provided, the term means the travelling direction of the light at the center of three-dimensional light flux from two or more light emitting elements. Hereinafter, an emitting direction along optical axis LA of light emitting element **110**, that is, a forward direction of lighting device **100**, (direction A illustrated in FIG. **2**) is referred to as a front side, and the opposite direction thereof, that is, a rear direction of lighting device **100**, (direction B illustrated in FIG. **2**) is referred to as a rear side.

(2) Light Flux Controlling Member

FIG. **3** is a cross-sectional view of light flux controlling member **120**. As illustrated in FIG. **3**, light flux controlling member **120** has first light flux controlling member **130**, second light flux controlling member **140** and holder **150**. Second light flux controlling member **140** is arranged on a front end of holder **150**, and first light flux controlling member **130** is arranged at a central portion of holder **150**. First light flux controlling member **130** opposes light emitting element **110**, and second light flux controlling member **140** opposes first light flux controlling member **130**. Any one of central axis CA**1** of first light flux controlling member **130**, central axis CA**2** of second light flux controlling member **140** and the central axis of holder **150** coincides with optical axis LA. In this manner, light flux controlling member **120** is arranged on optical axis LA.

(2-1) First Light Flux Controlling Member

FIGS. **4**A to **4**D are views illustrating configurations of first light flux controlling member **130** and holder **150**. FIG. **4**A is a plan view of first light flux controlling member **130** and holder **150**. FIG. **4**B is a side view of first light flux controlling member **130** and holder **150**. FIG. **4**C is a bottom view of first light flux controlling member **130** and holder **150**. FIG. **4**D is a cross-sectional view of first light flux controlling member **130** and holder **150** along the line D-D illustrated in FIG. **4**A.

As illustrated in FIG. **4**A, first light flux controlling member **130** is formed so that a shape when viewed in a plan view is a substantially circular shape. First light flux controlling member **130** is formed integrally with holder **150**, and is arranged with respect to light emitting element **110** via an air layer (refer to FIG. **2**). As illustrated in FIGS. **3** and **4**D, first light flux controlling member **130** has refraction portion **131**, Fresnel lens section **132** and emission surface **133**.

Refraction portion **131** is formed at the central portion on a rear side surface of first light flux controlling member **130**. Refraction portion **131** has a rotationally symmetric-shaped surface whose rotation axis is central axis CA**1**, and for example, the shape thereof in a plan view is circular. For example, refraction portion **131** is configured to have a planar, a spherical, an aspherical or a refractive Fresnel lens, or a combination thereof. Refraction portion **131** refracts a part of light which is emitted from light emitting element **110** and is incident on refraction portion **131** toward the emission surface **133**. Refraction portion **131** functions as an incidence surface of the light on which a part of the light emitted from light emitting element **110** is incident.

Fresnel lens section **132** is formed around refraction portion **131** on a rear side surface of first light flux controlling member **130**. Fresnel lens section **132** has a plurality of annular projections **132**a which are arranged concentrically.

Annular projections **132***a* each have first inclined surface **132***b* positioned inside and second inclined surface **132***c* positioned outside.

First inclined surface **132***b* is a surface extending from a top edge of annular projection **132***a* to a bottom edge inside annular projection **132***a*, and is a rotationally symmetric surface whose rotation axis is central axis CA**1** of first light flux controlling member **130**. That is, first inclined surface **132***b* is formed in an annular shape whose rotation axis is central axis CA**1**. Inclination angles of first inclined surface **132***b* with respect to central axis CA**1** may be different from each other. In addition, first inclined surface **132***b* may be parallel with central axis CA**1** (inclination angle 90°). Furthermore, a generating line of first inclined surface **132***b* may be a straight line, or may be a curve.

The term "generating line" generally means a straight line to draw a ruled surface, but in the present invention, is used as a term also including a curve to draw a rotationally symmetric surface. The inclination angle of first inclined surface **132***b* when first inclined surface **132***b* is a curved surface is an angle of a tangent of first inclined surface **132***b* with respect to central axis CA**1**. First inclined surface **132***b* functions as an incidence surface of light on which a part of the light emitted from light emitting element **110** is incident.

Second inclined surface **132***c* is a surface extending from a top edge of annular projection **132***a* to a bottom edge outside annular projection **132***a*. Second inclined surface **132***c* is a rotationally symmetric surface whose rotation axis is central axis CA**1** of first light flux controlling member **130**. A distance from central axis CA**1** to second inclined surface **132***c* is gradually increased from the top edge of annular projection **132***a* toward the bottom edge. The generating line configuring second inclined surface **132***c* is an arc-shaped curve which is convex outward (side away from ventral axis CA**1**). For example, depending on light distribution characteristics required for lighting device **100**, the generating line configuring second inclined surface **132***c* may be a straight line. That is, second inclined surface **132***c* may be a tapered surface.

The inclination angles of second inclined surface **132***c* with respect to central axis CA**1** may be different from each other for each of second inclined surfaces **132***c*. The inclination angle of second inclined surface **132***c* when second inclined surface **132***c* is a curved surface is an angle of the tangent of second inclined surface **132***c* with respect to central axis CA**1**. Flange **134** is disposed between an outer edge of outermost second inclined surface **132***c* and an inner surface of holder **150**. Flange **134** may not be disposed.

Second inclined surface **132***c* totally reflects a part of light incident on first inclined surface **132***b* toward second light flux controlling member **140**. Second inclined surface **132***c* functions as a total reflection surface which totally reflects a part of light which is incident from first inclined surface **132***b*. That is, Fresnel lens section **132** functions as a reflection type Fresnel lens.

Emission surface **133** configures a front side surface of first light flux controlling member **130**. That is, emission surface **133** opposes second light flux controlling member **140**. Emission surface **133** emits a part of light which is incident from refraction portion **131** and first inclined surface **132***b* and light which is totally reflected on second inclined surface **132***c*, toward second light flux controlling member **140**.

A material of first light flux controlling member **130** is not particularly limited as long as the material has high transparency which allows light of a desired wavelength to pass therethrough. For example, the material of first light flux controlling member **130** is a light-transmitting resin such as polymethyl methacrylate (PMMA), polycarbonate (PC) and epoxy resin (EP), or glass. For example, first light flux controlling member **130** is formed by injection molding.

First light flux controlling member **130** controls a travelling direction of a part of light emitted from light emitting element **110**. More specifically, first light flux controlling member **130** emits a part of light which is emitted from light emitting element **110** and reaches first light flux controlling member **130**, toward second light flux controlling member **140**. In this manner, first light flux controlling member **130** functions so that light distribution of light emitted from first light flux controlling member **130** is narrower than light distribution of the light emitted from light emitting element **110**.

(2-2) Second Light Flux Controlling Member

FIGS. **5**A to **5**D are views illustrating a configuration of second light flux controlling member **140**. FIG. **5**A is a plan view of second light flux controlling member **140**, FIG. **5**B is a side view of second light flux controlling member **140**, FIG. **5**C is a bottom view of second light flux controlling member **140**, and FIG. **5**D is a cross-sectional view of second light flux controlling member **140** along the line D-D illustrated in FIG. **5**A. As illustrated in FIG. **5**A, second light flux controlling member **140** is formed in a substantially circular shape in a plan view. Second light flux controlling member **140** is arranged with respect to first light flux controlling member **130** via an air layer (refer to FIG. **3**). Second light flux controlling member **140** has reflection surface **141**. Reflection surface **141** faces to first light flux controlling member **130**.

Reflection surface **141** is a rotationally symmetric (circularly symmetric) surface whose rotation axis is central axis CA**2** of second light flux controlling member **140**. A generating line from the center of the rotationally symmetric surface to the outer peripheral portion is a curve which is concave toward light emitting element **110** and first light flux controlling member **130**. Reflection surface **141** is a curved surface formed in case where the generating line is rotated 360°. That is, reflection surface **141** has an aspherically-shaped curved surface in which a height from light emitting element **110** in a direction of optical axis LA is increased from the center toward the outer peripheral portion.

The outer peripheral portion of reflection surface **141** is formed at a farther position away from light emitting element **110** in the direction of optical axis LA of light emitting element **110**, compared to the center of reflection surface **141**. For example, reflection surface **141** is the aspherical-shaped curved surface in which a distance from light emitting element **110** is increased from the center toward the outer peripheral portion. In this case, an angle of reflection surface **141** with respect to central axis CA**2** is increased from the center toward the outer peripheral portion.

Alternatively, reflection surface **141** may be the aspherical-shaped curved surface in which: a distance to light emitting element **110** in the direction of central axis CA**2** is increased from the central portion toward the outer peripheral portion in an area from the central portion to a predetermined point; and, a distance to light emitting element **110** is decreased from the central portion toward the outer peripheral portion in an area from the predetermined point to the outer peripheral portion. In this case, a point whose angle with respect to central axis CA**2** is 90° is present close to the outer peripheral portion, between the central portion and the outer peripheral portion on the reflection surface **141**.

It is preferable that reflection surface **141** be formed so that reflection intensity of incident light in a regular reflection direction is greater than reflection intensity of incident light in the other direction. Therefore, it is preferable that a surface of second light flux controlling member **140** which opposes first light flux controlling member **130** be a glossy surface.

Second light flux controlling member **140** further includes flange **142** surrounding the further outside of the outer peripheral portion of reflection surface **141**, fitting portion **143** formed at an end portion of flange **142** in the circumferential direction and protruding further outward from flange **142**, and recess **144** formed in fitting portion **143**.

Second light flux controlling member **140** has a function of partial reflection and partial transmission. Means for providing second light flux controlling member **140** with such a function of the partial reflection and the partial transmission is not particularly limited.

For example, the above-described function can be provided for second light flux controlling member **140** by forming a transmission reflection film on a rear side surface of second light flux controlling member **140** formed of a light-transmitting material. An example of the light-transmitting material includes a transparent resin material such as polymethyl methacrylate (PMMA), polycarbonate (PC) and epoxy resin (EP), or glass. An example of the transmission reflection film includes a dielectric multilayer film such as a multilayer film of TiO_2 and SiO_2, a multilayer film of ZrO_2 and SiO_2 and a multilayer film Ta_2O_5 and SiO_2, and a thin metal film made of aluminum (Al) or the like.

In addition, the above-described function can be provided for second light flux controlling member **140** by diffusing scattered particles such as beads inside second light flux controlling member **140** formed of a light-transmitting material. That is, second light flux controlling member **140** may be formed of a material which reflects a part of light and transmits a part of the light.

Further, the above-described function can be provided for second light flux controlling member **140** by forming a light-transmitting portion in second light flux controlling member **140** formed of a light-reflecting material if necessary. An example of the light-reflecting material includes a white resin or metal. An example of the light-transmitting portion includes a through-hole or a bottomed-recess. In a case of the latter, the light emitted from light emitting element **110** and first light flux controlling member **130** is transmitted through a bottom portion of the recess (portion where the thickness is thinner). For example, it is possible to manufacture second light flux controlling member **140** which has both light-reflecting and light-transmitting functions by using white polymethyl methacrylate whose light-transmitting transmittance of visible light is approximately 20% and whose reflectance is approximately 80%.

Second light flux controlling member **140** controls a travelling direction of the light emitted from emission surface **133** of first light flux controlling member **130**. Second light flux controlling member **140** functions so as to transmit a part of the light emitted from first light flux controlling member **130** and emit the light a forward direction and a lateral direction of lighting device **100**, and so as to reflect and emit the remaining part of the light emitted from first light flux controlling member **130** a lateral direction and a rear direction of lighting device **100**.

With regard to a light emitting direction in the specification, the term "forward direction" may also mean a front side in the direction of optical axis LA, that is, a direction in which an emission angle is 0°. The term "lateral direction" may also mean a direction in which the emission angle is greater than 0° and equal to or smaller than 90°. The term "rear direction" may also mean a direction in which the emission angle is greater than 90° and equal to or smaller than 180°.

Reflection surface **141** reflects light which reaches reflection surface **141** toward the lateral direction and the rear direction. The light which reaches a position closer to the center of reflection surface **141** is reflected more forwardly than the light which reaches a position closer to an outer peripheral edge of reflection surface **141**. The light emitted toward the rear direction from light flux controlling member **120** is mainly the light reflected on the outer peripheral portion of reflection surface **141**. The light emitted toward the rear direction from light flux controlling member **120** is mainly emitted from an upper half portion of the outer peripheral surface of holder **150** in FIG. **2** (further forward side portion than first light flux controlling member **130**).

(2-3) Holder

Holder **150** has a light-transmitting function. A material of holder **150** is not particularly limited as long as the material allows light of a desired wavelength to pass therethrough. For example, the material of holder **150** is a light-transmitting resin such as polymethyl methacrylate (PMMA), polycarbonate (PC) and epoxy resin (EP), or glass.

As illustrated in FIGS. **3** and **4**A to **4**D, holder **150** is formed in a rotationally symmetric cylindrical shape whose rotation axis is central axis CA**1**. For example, holder **150** is formed in a substantially cylindrical shape. Holder **150** is formed by molding integrally with first light flux controlling member **130** arranged in a central portion thereof.

Holder **150** has a structure for fixing second light flux controlling member **140** at a front side end portion. For example, holder **150** has guide projections **152** and pawls **153** on end surface **151** of the front side of holder **150**. End surface **151** is formed over the entire inside circumference of the front side end portion of holder **150**.

The number of guide projections **152** is not particularly limited, but is generally two or more. For example, as illustrated in FIGS. **4**A to **4**D, holder **150** has two guide projections **152** which oppose each other. A shape of guide projection **152** is not particularly limited as long as guide projection **152** can be fitted to second light flux controlling member **140** in a radial direction of holder **150**. For example, the shape of guide projection **152** in a plan view is a circular arc shape as illustrated in FIGS. **4**A to **4**D.

The number of pawls **153** is not particularly limited, but is generally two or more. For example, as illustrated in FIGS. **4**A to **4**D, holder **150** has two pawls **153** which oppose each other. In addition, a shape of pawl **153** is not particularly limited as long as pawl **153** can be fitted to recess **144** of second light flux controlling member **140** when second light flux controlling member **140** is rotated.

In addition, holder **150** has a structure for positioning holder **150** with respect to housing **170** at a rear side end portion of holder **150**. For example, at the rear side end portion of holder **150**, holder **150** has boss **155** for positioning holder **150** on housing **170**, vent **156** for ventilating air around first light flux controlling member **130**, and locking pawl **157** which locks into a locking hole (not illustrated) formed in an upper surface of housing **170**.

In a case of providing a light diffusing function to holder **150**, scattered particles may be included in the above-described light-transmitting material, or a surface of holder **150** may be subjected to light diffusion processing.

Light flux controlling member **120** is manufactured by assembling second light flux controlling member **140** with an integrally molded product of first light flux controlling member **130** and holder **150**. For example, the integrally molded product of first light flux controlling member **130** and holder **150** can be manufactured through injection molding by using colorless and transparent resin materials. For example, second light flux controlling member **140** can be manufactured by depositing a transparent reflection film on a surface serving as a reflection surface **141** after injection molding with the colorless and transparent resin materials, or by injection molding with a white resin material.

Second light flux controlling member **140** is fixed to a front side end portion of holder **150** in such a manner that flange **142** and fitting portion **143** are placed on end surface **151** and are rotated in this state. Guide projection **152** comes into contact with an outer peripheral surface of flange **142**, thereby preventing second light flux controlling member **140** from moving in a radial direction of holder **150**. Pawl **153** locks into recess **144**, thereby preventing second light flux controlling member **140** from being released and rotated.

Flange **142** comes into contact with an entire circumference of end surface **151**, thereby preventing light from leaking from a gap between second light flux controlling member **140** and holder **150**. When second light flux controlling member **140** is assembled, an adhesive may be used. Holder **150** is positioned on housing **170**, and positions first light flux controlling member **130** and second light flux controlling member **140** with respect to light emitting element **110**.

Light flux controlling member **120** may be manufactured by separately forming first light flux controlling member **130** and holder **150** and by assembling first light controlling member **130** and second light flux controlling member **140** with holder **150**. A degree of freedom is improved in selecting a material for forming holder **150** and first light flux controlling member **130** by separately forming first light flux controlling member **130** and holder **150**. For example, light flux controlling member **120** having holder **150** made of a light-transmitting material including the scattered particles and first light flux controlling member **130** made of light-transmitting material excluding the scattered particles can be easily prepared.

(3) Cover

Cover **160** has an opening. Cover **160** forms a hollow cavity area. Light flux controlling member **120** is arranged inside the hollow cavity area of cover **160**.

Cover **160** has a light-transmitting function. For example, the material of cover **160** is a light-transmitting resin such as polymethyl methacrylate (PMMA), polycarbonate (PC) and epoxy resin (EP), or glass. Cover **160** also has light diffusion. Means for providing light diffusion for cover **160** is not particularly limited. For example, an inner surface or an outer surface of cover **160** made of a transparent material may be subjected to light diffusion processing (for example, surface roughening processing), or cover **160** may be made of a material prepared by mixing a light diffusion material including the scattered particles such as beads with the above-described transparent material.

For example, an outer surface or an inner surface of cover **160** may be smooth or may be roughened. Irregularities in illuminance of lighting device **100** can be decreased by roughening the outer surface or the inner surface of cover **160**.

In general, it is preferable that cover **160** have a rotationally symmetric shape with respect to optical axis LA. For example, a shape of cover **160** may be a shape formed only from the rotationally symmetric shape, or may be a shape including a portion of the rotationally symmetric shape. It is preferable that the shape of cover **160** be a shape which can further improve a balance of light distribution of light emitted from light flux controlling member **120**.

For example, from a viewpoint of further increasing an amount of light toward the rear direction of lighting device **100**, it is preferable that the shape of cover **160** have a smaller diameter of the cover opening than a maximum outer diameter of cover **160**. For example, the shape of cover **160** is a spherical crown shape (portion of a spherical surface is cut out in a plane). A maximum outer diameter D1 of cover **160** is 60 mm, for example. An opening diameter D2 of cover **160** is 38 mm, for example (refer to FIG. **2**).

Cover **160** covers light flux controlling member **120**, and diffuses and transmits light emitted from light flux controlling member **120**.

(4) Housing

Housing **170** supports light emitting element **110**, light flux controlling member **120** and cover **160** respectively at the front end portion of housing **170**. Housing **170** is formed in a rotationally symmetric body whose rotation axis is optical axis LA. As illustrated in FIG. **6**, housing **170** includes Edison screw **171**, first tapered surface **172** which is arranged in front of Edison screw **171** wherein a distance from optical axis LA to first tapered surface **172** is gradually increased toward the forward direction, second tapered surface **173** in which a distance from optical axis LA to second tapered surface **173** is gradually decreased toward the forward direction from front end edge **172***a* of first tapered surface **172**, annular end surface **174** which is formed inside of the front end edge of second tapered surface **173** and is configured in an annular plane perpendicular to optical axis LA, and cylindrical protruding portion **175** protruding forward from an inner peripheral edge of annular end surface **174**.

Light emitting element **110** is mounted on a circular front end surface of protruding portion **175**. As illustrated in FIG. **2**, boss **155** of light flux controlling member **120** comes into contact with a front end peripheral portion of protruding portion **175** from outside. A distance from annular end surface **174** to a front end surface of protruding portion **175** (protruding length of protruding portion **175**) in the direction of optical axis LA is 3 mm, for example. The opening of cover **160** is in contact with annular end surface **174**. An outer diameter of annular end surface **174** is substantially the same as a diameter of the opening of cover **160**. Annular end surface **174** is a pedestal with which the opening of cover **160** comes into contact. Second tapered surface **173** is a tapered surface in which a distance from optical axis LA to second tapered surface **173** is gradually increased toward the rear direction from a peripheral edge of the pedestal.

A power supply circuit (not illustrated) which electrically connects Edison screw **171** and light emitting element **110** is arranged in an inside area surrounded by first tapered surface **172** and second tapered surface **173** of housing **170**. In addition, housing **170** also serves as a heat sink for radiating heat generated from light emitting element **110**. Therefore, housing **170** is made of a metal having high thermal conductivity such as aluminum and copper.

The shape of housing **170** is determined depending on light distribution characteristics of light flux controlling member **120**. Herein, the light distribution characteristics of light flux controlling member **120** will be described. First, an optical path of light in light flux controlling member **120** will be described.

The light being incident at a small angle with respect to optical axis LA of light emitting element **110** is incident on first light flux controlling member **130** from refraction portion **131**, and is emitted from emission surface **133**, and reaches second light flux controlling member **140**. The light being incident at a large angle with respect to optical axis LA of light emitting element **110** is incident on first inclined surface **132***b* of first light flux controlling member **130**, and is reflected on second inclined surface **132***c* toward second light flux controlling member **140**, and is emitted from emission surface **133**, and reaches second light flux controlling member **140**.

A part of the light which reaches second light flux controlling member **140** passes through second light flux controlling member **140** and reaches an upper portion of cover **160**. The remaining part of the light which reaches second light flux controlling member **140** is reflected on reflection surface **141** of second light flux controlling member **140**, and reaches holder **150**, and is emitted from an outer peripheral surface of holder **150**, and reaches a middle portion (side portion) and a lower portion of cover **160**. The light reflected on a central portion of second light flux controlling member **140** is emitted toward the middle portion of cover **160**, and the light reflected on an outer peripheral portion of second light flux controlling member **140** is emitted toward the lower portion of cover **160**.

FIG. **7** is a view illustrating light distribution of the light emitted from light flux controlling member **120** by using a relative value of luminous intensity. In FIG. **7**, the terms "0°" and "±180°" mean an orientation of optical axis LA. The term "0°" means the front direction. An angle oriented further to the left side than optical axis LA with respect to the front direction is indicated by "+", and an angle of a further right side orientation is indicated by "−". The luminous intensity is approximately equal to illuminance at a distance of 1 m from a light source. The light emitted from light emitting element **110** is distributed toward the forward direction, the lateral direction and the rear direction by light flux controlling member **120**. In particular, as illustrated in FIG. **7**, the light is distributed to have peaks at a lateral area) (±60° and peaks at a rear area (±120° to ±150°).

The term "peak" of the light emitted toward the rear direction is an apex of a portion of a light distribution characteristic curve which is shaped to protrude in an outer peripheral direction in the rear area. When a plurality of peaks is present in the rear area, the above-described "peak" is the largest peak. When a plurality of the largest peaks is substantially present, the above-described "peak" is a peak further rearward. When the above-described protruding shape in the rear area is not clear, the peak may be a maximum value of the luminous intensity in the rear area.

The peak in the rear area is illustrated by arrow B in FIG. **7**, and an angle θ thereof is ±132°, for example. Angle θ may be a measured value, or may be a calculated value obtained by computer simulation. As illustrated in FIG. **7**, the light emitted from light flux controlling member **120** at angle θ is strongest out of the light in the rear area.

Within the outer shape of housing **170**, protruding portions with respect to the optical path of the light of angle θ which is emitted from light flux controlling member **120** are the front end edge of second tapered surface **173** and front end edge **172***a* of first tapered surface **172**. Then, front end edge **172***a* of first tapered surface **172** protrudes to the above-described optical path further than the front end edge of second tapered surface **173**.

As illustrated in FIG. **6**, a position of front end edge **172***a* of first tapered surface **172** with respect to optical axis LA is determined by a position where when tangent L1 which comes into contact with front end edge **172***a* of first tapered surface **172** is drawn from an outer peripheral edge of reflection surface **141**, angle α formed by tangent L1 with optical axis LA is equal to or greater than above-described angle θ of the peak of the light in the rear area. In any cross-section including optical axis LA, tangent L1 is a tangent which comes into contact with housing **170** from the outer peripheral edge of reflection surface **141**, and an extension line thereof.

For both θ and α, a light emitting direction (direction A) side in optical axis LA is set to 0°. For example, α is 159.5°. For example, α is further increased by moving front end edge **172***a* of first tapered surface **172** closer to optical axis LA. In addition, α is further increased by further increasing a protruding height of protruding portion **175**.

In addition, as illustrated in FIG. **6**, when tangent L2 which comes into contact with second tapered surface **173** is drawn, second tapered surface **173** is formed so that angle β formed by tangent L2 with optical axis LA is equal to or greater than θ. In any cross-section including optical axis LA, tangent L2 is a straight line along second tapered surface **173**.

For β, a light emitting direction (direction A) side of the light in optical axis LA is also set to 0°. For example, β is 145.2°. β indicates an angle of second tapered surface **173** with respect to optical axis LA, and for example, is further increased by moving front end edge **172***a* of first tapered surface **172** closer to optical axis LA.

(Optical Characteristics of Lighting Device)

FIG. **8**A is a view schematically illustrating light emitted toward the rear direction of lighting device **100**, and FIG. **8**B is a view illustrating light distribution of lighting device **100** by using a relative value of luminous intensity.

Within light emitted from light flux controlling member **120**, the light emitted toward the rear direction is emitted from the outer peripheral surface of holder **150**. Then, as described above, within the light emitted toward the rear direction, the strongest light emitted at angle θ (light of angle θ) is mainly emitted from a forward half of the outer peripheral surface of holder **150** (further front side portion than first light flux controlling member **130**), as illustrated by arrow B in FIG. **8**A. Furthermore, within the outer shape of housing **170**, front end edge **172***a* of first tapered surface **172** is most protruded with respect to the optical path of the light of angle θ.

As described above, an angle formed by tangent L1 which comes into contact with front end edge **172***a* of first tapered surface **172** from the outer peripheral edge of reflection surface **141** with optical axis LA is α, and α is equal to or greater than θ. Therefore, the light reflected on the outer peripheral portion of reflection surface **141** (light of angle θ), which is main component of the light emitted toward the rear direction, travels an optical path which comes into contact with front end edge **172***a* of first tapered surface **172**, or a further outer optical path, the optical path not being coming into contact with front end edge **172***a*.

Accordingly, housing **170** shaped so that α is equal to or greater than θ does not block the light of angle θ which is emitted from light flux controlling member **120**. Therefore, light emitted toward the rear direction from light flux controlling member **120** at angle θ is not blocked by housing **170**, is directly incident on cover **160** and is emitted from cover **160**. The light emitted toward the forward direction and the lateral direction from light flux controlling member **120** is also directly incident on cover **160** and is emitted from cover **160**.

In this manner, the light emitted from light flux controlling member **120** is substantially emitted toward all directions and is incident on cover **160**. The light incident on cover **160** is further diffused in each orientation by cover **160**, and is uniformly emitted toward all directions from cover **160**. Therefore, as illustrated in FIG. **8**B, the light emitted from lighting device **100** is distributed toward not only the forward direction but also the lateral direction and the rear direction with a good balance.

(Advantageous Effect)

In lighting device **100**, first light flux controlling member **130** concentrates the light emitted from light emitting element **110** on second light flux controlling member **140**, and second light flux controlling member **140** transmits a part of the light and reflects the remaining part toward the lateral direction and the rear direction. Then, housing **170** is formed in a shape where angle α formed by tangent L1 which comes into contact with housing **170** from the outer peripheral edge of reflection surface **141** with optical axis LA is equal to or greater than peak angle θ of the light emitted toward the rear direction. Therefore, the light emitted from light flux controlling member **120** is not blocked by housing **170**, is emitted toward substantially all directions, and is directly incident on cover **160**, and passes through cover **160** while being diffused, and is emitted outward. As a result, lighting device **100** can emit the light distributing toward the forward, lateral and rear directions with a good balance.

Furthermore, in lighting device **100**, second tapered surface **173** is inclined at angle β which is equal to or greater than θ. Therefore, light within the light of angle θ which passes through the vicinity of the opening of cover **160** is not blocked by second tapered surface **173**. As a result, an entire inner surface area of cover **160** from an apex of cover **160** to the opening can be effectively used as an incidence surface. Therefore, it is more effective from a viewpoint that cover **160** further enhances the effect in improving light distribution characteristics. In addition, since housing **170** has second tapered surface **173**, the peak light toward the rear direction is not blocked. Consequently, it is also effective from a viewpoint of ensuring a sufficient capacity of housing **170**.

Furthermore, in lighting device **100**, cover **160** is formed in a spherical crown shape which has a smaller opening diameter than the maximum outer diameter. Therefore, it is more effective from a viewpoint of emitting the light inside cover **160** toward the rear direction and from a viewpoint of adjusting a balance in light distribution in all directions.

(Embodiment 2)

FIG. **9**A is a view schematically illustrating light emitted toward the rear direction of lighting device **200** according to Embodiment 2, and FIG. **9**B is a view illustrating light distribution of lighting device **200** by using a relative value of luminous intensity. Lighting device **200** is configured similar to lighting device **100** except for three different points of protruding portion **175**, first tapered surface **172** and second tapered surface **173**. The same reference numerals are given to the same configurations as for lighting device **100** and the description thereof will be omitted.

Protruding portion **275** is configured similar to protruding portion **175** except that a protruding length from an annular end surface in the direction of optical axis LA is different. The protruding length of protruding portion **275** is 15.5 mm, for example. The length of first tapered surface **272** in the direction of optical axis LA is shorter than that of first tapered surface **172**. The length of second tapered surface **273** in the direction of optical axis LA is shorter than that of second tapered surface **173**. It is the same as lighting device **100** in that within the outer shape of housing **270**, front end edge **272***a* of first tapered surface **272** is a most protruding portion with respect to the optical path of the light of angle θ. Angle α formed by tangent L1 which passes through the outer peripheral edge of reflection surface **141** and comes into contact with front end edge **272***a* of first tapered surface **272** with optical axis LA is greater than θ. In addition, inclination angle β of second tapered surface **273** is smaller than θ.

In lighting device **200**, inclination angle β of second tapered surface **273** is smaller than θ, but the protruding length of protruding portion **275** is sufficiently long. Therefore, the peak light in the rear area which is emitted from light flux controlling member **120** is not blocked by second tapered surface **273**. Accordingly, as illustrated in FIG. **9**B, lighting device **200** can also emit light distributing toward the forward, the lateral and the rear directions with a good balance.

Furthermore, in lighting device **200**, light emitting element **110** is arranged at a central portion of a hollow region inside cover **160**. Thus, a length of a portion of housing **270** from a rear end of Edison screw to the front end edge of second tapered surface **273** in the direction of optical axis LA is further shortened. Accordingly, according to the present embodiment, it is possible to configure a lighting device which has the same cover **160** as lighting device **100** and has a shorter full length than lighting device **100**.

(Embodiment 3)

FIG. **10**A is a view schematically illustrating light emitted toward the rear direction of lighting device **300** according to Embodiment 3, and FIG. **10**B is a view illustrating light distribution of lighting device **300** by using a relative value of luminous intensity. Lighting device **300** is configured similar to lighting device **100** except that a size of cover **160** is different. The same reference numerals are given to the same configurations as for lighting device **100** and the description thereof will be omitted.

A maximum outer diameter of cover **360** is smaller than that of cover **160**. The maximum outer diameter of cover **360** is 49 mm, for example. Light flux controlling member **120** and housing **170** are the same as those of lighting device **100**. Thus, for the same reason as described in lighting device **100**, the peak light in the rear area which is emitted from light flux controlling member **120** is not blocked by housing **170**. Accordingly, as illustrated in FIG. **10**B, lighting device **300** can also emit light distributing toward the forward, the lateral and the rear directions with a good balance. According to the present embodiment, it is possible to configure a lighting device which has the same housing **170** as lighting device **100** and has a shorter full-length than lighting device **100**.

COMPARATIVE EXAMPLE 1

FIG. **11**A is a view schematically illustrating light emitted toward the rear direction of lighting device **400** for comparison, and FIG. **11**B is a view illustrating light distribution of lighting device **400** by using a relative value of luminous intensity. Lighting device **400** for comparison is different from lighting device **100** in a size of cover **160** and a shape of housing **170**.

Housing **470** of lighting device **400** for comparison does not have second tapered surface **173**. Accordingly, annular end surface **474** is formed to start from a front end edge of first tapered surface **472**. In addition, both a maximum outer diameter and an opening diameter of cover **460** of lighting device **400** for comparison are larger than those of cover **160**. The maximum outer diameter of cover **460** is 70 mm, for example. The opening diameter of cover **460** is 68 mm, for example. The opening of cover **460** is arranged on the outer peripheral edge of annular end surface **474**, and the outer peripheral surface of cover **460** is substantially integral and continuous with the outer peripheral surface of housing **470**.

In lighting device **400**, annular end surface **474** protrudes outward at a smaller angle) (±90°) than angle θ of the peak light in the rear area which is emitted from light flux controlling member **120**, and the opening of cover **460** is arranged in the outer peripheral edge of annular end surface **474**. Then, as illustrated in FIG. **11**A, angle α formed by tangent L1 which passes through the outer peripheral edge of reflection surface

141 and comes into contact with the outer peripheral edge (front end edge **472***a* of first tapered surface **472**) of annular end surface **474** with optical axis LA is smaller than θ. Therefore, in lighting device **400**, before reaching cover **460**, the peak light in the rear area which is emitted from light flux controlling member **120** is blocked by annular end surface **474**. Accordingly, as illustrated in FIG. **11**B, luminous intensity in the rear in lighting device **400** is obviously lower compared to lighting devices **100** to **300**.

COMPARATIVE EXAMPLE 2

FIG. **12**A is a view schematically illustrating light emitted toward the rear direction of lighting device **500** for comparison, and FIG. **12**B is a view illustrating light distribution of lighting device **500** by using a relative value of luminous intensity. Lighting device **500** for comparison is configured similarly to lighting device **400** for comparison except that cover **460** is different. A cover in lighting device **500** for comparison is the same as cover **160** in lighting device **100** according to Embodiment 1 of the present invention.

The opening of cover **160** is arranged in an inner peripheral edge side of annular end surface **474**, and annular end surface **474** protrudes further outward than the opening of cover **160**. Then, as illustrated in FIG. **12**A, angle α formed by tangent L1 which passes through the outer peripheral edge of reflection surface **141** and comes into contact with the outer peripheral edge (front end edge **472***a* of first tapered surface **472**) of annular end surface **474** with optical axis LA is smaller than θ.

Therefore, in lighting device **500**, the peak light in the rear area which is emitted from light flux controlling member **120** directly reaches cover **160**. However, the above-described peak light which is emitted from cover **160** is blocked by annular end surface **474**. Accordingly, as illustrated in FIG. **12**B, luminous intensity toward the rear direction of lighting device **500** is obviously lower compared to lighting devices **100** to **300**.

MODIFICATION EXAMPLE

In the present invention, instead of light flux controlling member **120**, as illustrated in FIG. **13**, a light flux controlling member, which has first light flux controlling member **230** excluding Fresnel lens section **132** as a first light flux controlling member, can be used. FIG. **13**A is a plan view of an integrally molded product of first light flux controlling member **230** and holder **150**, FIG. **13**B is a side view of the integrally molded product, FIG. **13**C is a bottom view of the integrally molded product, and FIG. **13**D is a cross-sectional view of the integrally molded product along the line D-D illustrated in FIG. **13**A. The same reference numerals are given to the same configurations as for first light flux controlling member **120** and holder **150**, and the description thereof will be omitted.

First light flux controlling member **230** has incidence surface **231** on which light emitted from light emitting element **110** is incident, total reflection surface **232** which totally reflects a part of the light incident from incidence surface **231**, and emission surface **133** which emits a part of the light incident from incidence surface **231** and the light reflected on total reflection surface **232**.

Incidence surface **231** is an inner surface of a recess formed at a bottom portion of first light flux controlling member **230**. Incidence surface **231** includes an inner upper surface configuring an upper surface of the recess and a tapered inner side surface configuring a side surface of the recess. In the inner side surface, an inner diameter is gradually increased toward the opening edge side from the inner upper surface side so that an inner diameter dimension of the opening edge side is larger than an inner diameter dimension of the edge of the inner upper surface side (refer to FIG. **13**D).

Total reflection surface **232** is a surface extending from an outer edge of the bottom portion of first light flux controlling member **230** to an outer edge of emission surface **133**. Total reflection surface **232** is a rotationally symmetric surface whose rotation axis is central axis CA**1** of first light flux controlling member **230**. The diameter of total reflection surface **232** is gradually increased from the bottom portion toward emission surface **133**. The generating line configuring total reflection surface **232** is an arc-shaped curve which is convex outward (side away from central axis CA**1**). The generating line configuring total reflection surface **232** may be a straight line and total reflection surface **232** may have a tapered shape.

A light flux controlling member is configured by mounting second light flux controlling member **140** on the integrally molded product as described above. Instead of light flux controlling member **120**, even by using the above-described light flux controlling member, it is possible to obtain a lighting device having light distribution characteristics similar to the incandescent lamp.

Furthermore, irregularities for adjusting an emitting direction of light emitted from a holder may be formed on an outer peripheral surface of the holder. FIG. **14**A is a view illustrating an example of enlarged irregularities formed on the outer peripheral surface of the holder. FIG. **14**B is a view illustrating another example of the enlarged irregularities formed on the outer peripheral surface of the holder.

Multiple recesses **351** have the same shape as each other and are arranged at regular intervals. The shape of recess **351** is rotationally symmetric whose rotation axis is a central axis (for example, central axis CA**1** or CA**2**) of holder **150**. The shape of recess **351** in a cross section which passes through the central axis of holder **150** is a right triangle.

As illustrated in FIG. **14**A, recess **351** has inclined surface **351***a* in which an outer diameter of holder **150** is gradually decreased toward the rear side of holder **150** and annular plane **351***b* which extends outward from a rear side end of inclined surface **351***a* and is orthogonal to the central axis of holder **150**. Inclined surface **351***a* changes a travelling direction of light which is reflected on second light flux controlling member **140** and reaches holder **150** from the front side of holder **150** so as to be close to a direction orthogonal to optical axis LA of light emitting element **110**.

A recess may be recess **352** illustrated in FIG. **14**B. Recess **352** has inclined surface **351***c* in which the outer diameter of holder **150** is gradually decreased toward the front side of holder **150** and plane **351***d* which extends outward from a front side end of inclined surface **351***c* and is orthogonal to the central axis of holder **150**. Recess **352** changes a travelling direction of light which reaches holder **150** from the rear side of holder **150** so as to be close to a direction orthogonal to optical axis LA of light emitting element **110** (sideward).

The shape of the recess is not particularly limited as long as there is provided a surface, such as inclined surface **351***a* and inclined surface **351***c*, which changes the travelling direction of the light from the front side or from the rear side so as to be close to a lateral direction. Such a surface also includes a surface whose generating line is a curve. Instead of holder **150** described above, even by using the holder having irregularities, it is possible to obtain a lighting device having light distribution characteristics similar to the incandescent lamp.

In addition, the shape of the housing is not limited to the shape including the tapered surface. For example, the housing may be formed in a columnar body which is straight along optical axis LA. The shape of the housing is not limited to a shape which is rotationally symmetric. For example, the shape of a cross section which is orthogonal to optical axis LA of the housing may be a polygon such as a rectangle, or may be a non-circular shape such as an elliptical shape. Even by using such a housing, as long as the housing has a shape which satisfies the above-described relationship between a and **0**, it is possible to obtain a lighting device having light distribution characteristics similar to the incandescent lamp.

INDUSTRIAL APPLICABILITY

A lighting device according to the present invention can be widely applied to various pieces of illumination equipment such as chandeliers and indirect lighting devices, since the apparatus can be used instead of an incandescent lamp.

REFERENCE SIGNS LIST

10, **100** to **500** Lighting device
11 LED
12 Light emission surface
13, **160**, **360**, **460** Cover
14,**171** Edison screw
110 Light emitting element
120 Light flux controlling member
130, **230** First light flux controlling member
131 Refraction portion
132 Fresnel lens section
132*a* Annular projection
132*b* First inclined surface
132*c* Second inclined surface
133 Emission surface
134, **142** Flange
140 Second light flux controlling member
141 Reflection surface
143 Fitting portion
144, **351**, **352** Recess
150 Holder
151 End surface
152 Guide projection
153 Pawl
155 Boss
156 Vent
157 Locking pawl
170, **270**, **470** Housing
172, **272**, **472** First tapered surface
172*a*, **272***a*, **472***a* Front end edge of first tapered surface
173, **273** Second tapered surface
174, **474** Annular end surface
175, **275** Protruding portion
231 Incidence surface
232 Total reflection surface
351*a*, **351***c* Inclined surface
351*b*, **351***d* Plane
CA, CA**1**, CA**2** Central axis
LA Optical axis

The invention claimed is:

1. A lighting device comprising:

a light emitting element for emitting light toward a forward direction of the lighting device;

a light flux controlling member for emitting a part of light, the light being emitted toward the forward direction from the light emitting element, toward a lateral direction or a rear direction of the lighting device, the light flux controlling member being arranged on an optical axis of the light emitting element, and comprising a first light flux controlling member and a second light flux controlling member;

a cover that covers the light flux controlling member for transmitting light emitted from the light flux controlling member with the light being diffused; and

a housing that supports the light emitting element, the light flux controlling member and the cover,

wherein the first light flux controlling member is arranged opposing the light emitting element for emitting a part of light that is emitted from the light emitting element and reaches the first light flux controlling member toward the second light flux controlling member,

the first light flux controlling member has an incidence surface on which a part of the light emitted from the light emitting element is incident, a total reflection surface that reflects a part of the light which has been incident on the incidence surface toward the second light flux controlling member, and an emission surface that emits a part of the light which has been incident on the incidence surface and the light which has been reflected on the total reflection surface toward the second light flux controlling member,

the second light flux controlling member has a reflection surface that faces to an emission surface of the first light flux controlling member for reflecting a part of light emitted from the first light flux controlling member and reaches the second light flux controlling member, and for transmitting the remaining light,

the reflection surface is a rotationally symmetric surface whose rotation axis is the optical axis, and a generating line of the rotationally symmetric surface is formed to be a concave curve with respect to the first light flux controlling member,

an outer peripheral portion of the reflection surface is disposed at a position away from the light emitting element in a direction of the optical axis, compared to a central portion of the reflection surface,

the light emitted from the light flux controlling member has a peak in luminous intensity distribution of the light in a rearward direction which is a direction opposite to the direction of the light emitted from the light flux controlling member along the optical axis, and

the housing has an outermost rim which is a most protruding portion relative to an optical path of light of angle θ

where, provided that an angle of an emitting direction of light emitted forward from the light flux controlling member along the optical axis is set to 0°, in any cross-section including the optical axis, α is one of two angles formed at an intersection between the optical axis and a line which is tangent to an outer rim of the reflection surface and the outermost rim of the housing, wherein:

α is the greater angle formed at the intersection, and θ represents an angle relative to the optical axis in the rearward direction of the peak of luminous intensity distribution of the light emitted from an outer peripheral surface of the light flux controlling member.

2. The lighting device according to claim **1**,

wherein the housing further has a base with which an opening of the cover comes in contact and the tapered surface inclines at an angle of β relative to the optical axis, wherein a distance between the tapered surface and the optical axis is gradually increased toward the rear direction of the lighting device from an outer rim of the base, and wherein the housing has a shape such that β is θ or greater, where, in any cross-section including the optical axis, β is one of two angles formed at an intersection between a straight line along the tapered surface and the optical axis, the β being the greater angle.

3. The lighting device according to claim **1**, wherein a shape of the cover is a spherical crown shape.

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